

**PRODUCTION OF LIGNOCELLULOSES
FROM PALM OIL EMPTY FRUIT BUNCH**

SITI MURNI BINTI MOHAMAD KHADRI

**A thesis submitted in fulfillment
of the requirements for the award of the degree of
Bachelor of Chemical Engineering**

**Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang**

APRIL 2010

ABSTRACT

Lignocelluloses were a significant new value added product especially for composite industries. The method of alkali and acid treatment was used in order to produces lignocelluloses from palm oil empty fruit bunch. This research obtained to identify the effect of temperature, size of palm oil empty fruit bunch and concentration of acid on production of lignocelluloses yield. The sample of palm oil empty fruit bunch was treated by sodium hydroxide and hydrochloric acid. Sodium hydroxide was used in order to breakdown all the lignin bonding in sample of palm oil empty fruit bunch. Hydrochloric acid was used as a bleaching treatment for lignocelluloses produces. The result shows the smallest size of palm oil empty fruit bunch was resulted high yield of lignocelluloses produces that was 80%. The lowest concentration was decrease the yield of lignocelluloses production that was 40%. Characteristic of lignocelluloses was found using SEM, TGA and FTIR. The morphological structure of lignocelluloses has been analyzing using SEM. The biggest sample of palm oil empty fruit bunch was resulted no breakage and better surface lignocelluloses produces. More stable structure was degrade at higher temperature that was resulted from TGA analyze. There are three functional groups consist in this lignocelluloses that were $\text{N}(\text{C}_2\text{H}_5)_4$, $\text{C}-\text{C}=\text{C}$ and $\text{O}-\text{H}$.

ABSTRAK

Lignocelluloses merupakan salah satu hasil penemuan baru yang mempunyai nilai tinggi terutamanya didalam industri composite. Penghasilan lignocelluloses daripada tandan kosong kelapa sawit adalah dengan menggunakan kaedah rawatan alkali dan acid. Kajian ini dapat menemukan kesan terhadap suhu, saiz tandan kosong kelapa sawit and kepekatan acid keatas kadar penghasilan lignocelluloses. Bahan kajian tandan kosong kelapa sawit telah dirawat menggunakan sodium hydroxide dan acid hydrochloric. Sodium hydroxide telah digunakan untuk tujuan memecahkan ikatan gentian lignin yang terkandung didalam tandan kosong kelapa sawit. Acid hydrochloric digunakan sebagai rawatan peluntur bagi membersihkan cairan hitam yang terhasil daripada tindakbalas sodium hydroxide didalam menghasilkan lignocelluloses. Hasil kajian menunjukkan penghasilan lignocelluloses adalah paling tinggi 80% apabila saiz terkecil digunakan. Kepekatan acid yang paling rendah akan menyebabkan kemerosotan kadar penghasilan lignocelluloses iaitu 40%. Struktur permukaan lignocelluloses telah dikaji dengan menggunakan mesin SEM. Semakin besar saiz tandan kelapa sawit kosong akan menghasilkan lignocelluloses yang mempunyai permukaan bagus dan tidak akan musnah. Semakin stable structure akan memerlukan suhu yang tinggi untuk memecahkan ikatan antara molekul lignocelluloses, ini dapat dilihat dengan hasil analysis menggunakan mesin TGA. Lignocelluloses yang dihasilkan mengandungi tiga kumpulan berfungsinya iaitu kumpulan alkane, amine dan alcohol.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	iii
	DEDICATION	v
	ACKNOWLEDGEMENTS	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF ABBREVIATIONS	xiii
	LIST OF SYMBOLS	xiv
 1	 INTRODUCTION	
	1.1 Background of Study	1
	1.2 Problem Statement	3
	1.3 Research Goal/ Objectives	3
	1.4 Research Advantage	4
 2	 LITERATURE REVIEW	
	2.1 Palm Oil Empty Fruit Bunch	5
	2.2 Lignocelluloses Structure	6
	2.2.1 Cellulose	7
	2.2.2 Hemicelluloses	7
	2.2.3 Lignin	8
	2.2.4 Pectins and Waxes	8
	2.3 Chemical Treatment of Lignocelluloses	8-9
	2.3.1 Alkali Treatment	9
	2.4 Characterization of Lignocelluloses	10

2.4.1	Scanning Electron Microscope (SEM)	10
2.4.2	Fourier Transform Infrared (FTIR)	11
2.4.4	Thermo Gravitation Analyzer (TGA)	12-13

3 RAW MATERIAL AND EQUIPMENT

3.1	Raw Material and Equipment	14
3.1.1	Chemical	15
3.1.2	Apparatus	16
3.1.3	Equipment	17
3.2	Methodology	17
3.2.1	Preparation Sample of Palm Oil	
	Empty Fruit Bunch	17
3.2.2	Treatment Process of Palm Oil	
	Empty Fruit Bunch	21
3.3	Yield of Lignocelluloses Determination	23
3.4	Lignocelluloses Characterization	23
3.4.1	Scanning Electron Microscope (SEM)	23
3.4.2	Fourier Transform Infrared (FTIR)	25
3.4.3	Thermo Gravitation Analyzer (TGA)	26

4 RESULTS AND DISCUSSION

4.1	The Effect of Size on Lignocelluloses Yield	27
4.2	The Effect of Concentration on	
	Lignocelluloses Yield	28
4.3	The effect of Temperature on	
	Lignocelluloses Yield	30
4.4	Optimum Size of POEFB Sample	31
4.4.1	The Temperature Effect on 45µm	
	of POEFB	32
4.4.2	The Concentration on 45µm	
	of POEFB	33
4.5	Analysis of Lignocelluloses	34
4.5.1	Thermo Gravimetric Analyzer (TGA)	34

4.5.2 Fourier Transform Infrared (FTIR) 37

4.5.3 Scanning Electron Microscope (SEM) 38

5 CONCLUSION & RECOMMENDATIONS

5.1 Conclusion 40

5.2 Recommendations 41

REFERENCES 42

APENDICES 43

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1.1	Lignocelluloses Composition from Different Source of Lignocellulose Materials	6
4.1	Result for the various size of sample	43
4.2	Result for the acid concentration	43
4.3	Result for the temperature	43
4.4	Result for repeated experiment on various temperatures	43
4.4	Result for repeated experiment on various concentrations	44

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
3.1	A lot of Palm oil empty fruit bunch produce from Palm Oil Mill	14
3.2	The Sampling Process	15
3.3	The cleaning process	18
3.4	The drying process	19
3.5	The process flow of sample preparation	20
3.6	Alkaline treatment	21
3.7	Acid treatment	22
3.8	Lignocelluloses	22
3.9	Scanning Electron Microscope (SEM)	24
3.10	Fourier Transform Infrared Spectroscopy (FTIR)	25
3.11	Thermo Gravitation Analyzer (TGA)	26
4.1	The Effect of Size on Lignocelluloses Yield	27
4.2	The Effect of Concentration on Lignocelluloses Yield	29
4.3	The effect of Temperature on Lignocelluloses Yield	30
4.4	The Temperature Effect on 45µm of POEFB	32
4.5	The Concentration on 45µm of POEFB	33
4.6	Result for the TGA analyze at sample size of 45µm	35
4.7	Result for the TGA analyze at sample size of 160µm	36
4.8	Result for the FTIR analyzes	37
4.9	Result for the SEM analyze on 160µm sample Size	38
4.10	Result for the SEM analyze on 45 µm sample size	39

LIST OF SYMBOLS/ABBREVIATIONS

NaOH	- Sodium Hydroxide
HCl	- Acid Hydrochloric
SEM	- Scanning Electron Microscope
FTIR	- Fourier Transform Infrared
TGA	- Thermo Gravitation Analyzer
EFB	- Empty Fruit Bunch
wt%	- Weight Percent
°C	- Degree Celsius
IR	- Infra Red
FPISB	- Felda Palm Industries Sdn Bhd
FKKSA	- Fakulti Kejuruteraan Kimia Sumber Asli
M	- Molar
µm	- Micrometer
POEFB	- Palm Oil Empty Fruit Bunch
pH	- Potential For Hydrogen Ion Concentration
FKM	- Fakulti Kejuruteraan Mekanikal
Ca	- Concentration
gm	- Gram
N(C ₂ H ₅) ₄	- Amine Group
C=C	- Alkenes Group
O-H	- Alcohol Group

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Lignocelluloses are the main structural component of wood plant and non wood plant such as palm oil empty fruit bunch. The chemical properties of the components of lignocellulosics make them a substrate of enormous biotechnological value (Howard et al. 2003). In Malaysia, the main sources of lignocelluloses come from palm oil empty fruit bunch as a palm oil residue. Nowadays, no more technology obtained to dispose this residue. Because of that, many palm oil mill use incineration process to dispose this residue. Effect of that, can contribute to the environmental pollution. Today, many researches was run in order to convert the palm oil empty fruit bunch as waste to become various value added product.

This study is to find the production of lignocelluloses palm oil empty fruit bunch. The study of production lignocelluloses from empty fruit bunch is one of process to recycle the palm oil mill residue. The chemical properties of the component of

lignocelluloses make them highly potential to become various value added product including biofuels, chemicals, cheap energy sources for fermentation, improved animal feeds and human nutrients. Lignocellulytic enzymes also have significant potential applications in various industries including chemicals, fuel, food, brewery and wine, animal feed, textile and laundry, pulp and paper, and agriculture.

In Malaysia, the palm oil empty fruit bunch is the one of palm oil mill residue. The palm oil empty fruit bunch was produce in the large amount is more than 8 million metric ton per annum (Shawkataly and Rozman, 2004). Much of the lignocelluloses waste is often disposed of by incineration, which is not restricted to developing countries alone, but is considered a global phenomenon. Because of that, it can contribute to the environmental pollution. So one of the way for save our environment is recycle the palm oil empty fruit bunch to become various value added product such as plastic compound filler and lignocelluloses.

This study was focused on the production of lignocelluloses from palm oil empty fruit bunch. The method of alkali and acid treatment was use in order to produce lignocelluloses from empty fruit bunch. The chemical that use in the alkali treatment is sodium hydroxide (NAOH) and hydrochloric acid (HCl) as solvent. The parameters that measure in this experiment is concentration of acid, temperature and also the size of oil palm empty fruit bunch. After experiment was done we will see relationship between the parameters and production of lignocelluloses.

1.2 Problem Statement

Palm oil empty fruit bunch is the one of palm oil mill residues 'waste'. Malaysia is one of the palm oil producers around the world. But the residue of the palm oil has still not been completely used. Palm oil empty fruit bunch was disposed by incineration process and it directly contributing to the environmental pollution.

Because of that, the purpose of this research is to convert the waste of palm oil empty fruit bunch into the value added product. The research title of my project is production of lignocelluloses from palm oil empty fruit bunch.

According to the previous research it was stated the physical properties of the palm oil empty fruit bunch make it highly potentials to become various value added product.

1.3 Research Goal/ Objectives

- i. To produces lignocelluloses from palm oil empty fruit bunch.
- ii. To obtained the effect of temperature, size of oil palm empty fruit bunch and concentration of acid on production of lignocelluloses.

1.4 Research Scope

- i. The effect of size, temperature and Acid concentration in production of lignocelluloses.
- ii. The optimum condition for production of lignocelluloses.
- iii. Analyze the lignocelluloses produce by using SEM, FTIR and TGA at the optimum condition.

1.5 Research Advantage

- i. Environmental friendly product will produce.
- ii. Creating new composite from natural resources of palm oil empty fruit bunch.
- iii. Recycle palm oil empty fruit bunch 'waste' as the value added product.
- iv. Lignocelluloses from palm oil empty fruit bunch as natural composite will produce for industrial needed.

CHAPTER 2

LITERATURE REVIEW

2.1 Palm Oil Empty Fruit Bunch

The Palm oil empty fruit bunch comes from palm oil tree (*Elais guineensis*) and is one of the by-products generated from palm oil mill. Malaysia is the largest producer of palm oil around the world with about more than twelve million tonnes every year (Nafpour et al 2007). Effect of that, many residues were generated from this industry and it became abundant biomass resources. Now days, many researchers were studying the potential of palm oil empty fruit bunch as a new profitable product such as ethanol, composite and lignocelluloses. The production of lignocelluloses from palm oil empty fruit bunch is highly potential in Malaysia. It is because, the palm oil empty fruit bunch is one source to produce lignocelluloses.

2.2 Lignocelluloses Structure

Lignocelluloses or natural fibers are subdivided based on their origins, coming from plants, animals or minerals. All plant fibers are composed of cellulose while animal fibers consist of proteins (hair, silk, and wool). Plant fibers include bast (or stem or soft sclerenchyma) fibers, leaf or hard fibers, seed, fruit, wood, cereal straw, and other grass fibers (John and Thomas, 2007). The main components of lignocelluloses are celluloses, hemicelluloses, lignin, pectin and waxes.

TABLE 1.1 Lignocelluloses Composition from Different Source of Lignocellulose Materials

Sources	Main Components (Percentage by Dry Weight)				
	Cellulose (%)	Xylan (%)	Hemicellulose (%)	Lignin (%)	Ash (%)
Palm Oil EFB	50.4	-	21.9	10.0	0.5
Sorghum Straw	35.0	19.0	24.0	25.0	-
Sugar Cane Bagasse	38.9	20.6	-	23.9	-
Corn Cobs	31.7	-	34.7	20.3	-
Rice Straw	43.4	20.2	28.0	17.2	11.4

(Source: Najafpour et al 2007)

2.2.1 Cellulose

Cellulose is a natural polymer consisting of D-anhydroglucose ($C_6H_{10}O_5$) repeating units joined by 1,4-b-D-glycosidic linkages at C1 and C4 position. The degree of polymerization (DP) is around 10,000. Each repeating unit contains three hydroxyl groups. These hydroxyl groups and their ability to hydrogen bond play a major role in directing the crystalline packing and also govern the physical properties of cellulose. Solid cellulose forms a microcrystalline structure with regions of high order i.e. crystalline regions and regions of low order i.e. amorphous regions. Cellulose is also formed of slender rod like crystalline microfibrils. The crystal nature (monoclinic sphenodic) of naturally occurring cellulose is known as cellulose I. Cellulose is resistant to strong alkali (17.5 wt%) but is easily hydrolyzed by acid to water-soluble sugars. Cellulose is relatively resistant to oxidizing agents (John and Thomas 2007).

2.2.2 Hemicellulose

Hemicellulose is not a form of cellulose and the name is a misnomer. They comprise a group of polysaccharides composed of a combination of 5- and 6-carbon ring sugars. Hemicellulose differs from cellulose in three aspects. Firstly, they contain several different sugar units whereas cellulose contains only 1,4-b-D-glucopyranose units. Secondly, they exhibit a considerable degree of chain branching containing pendant side groups giving rise to its non crystalline nature, whereas cellulose is a linear polymer. Thirdly, the degree of polymerization of native cellulose is 10–100 times higher than that of hemicellulose. The degree of polymerization (DP) of hemicellulose is around 50–300. Hemicelluloses form the supportive matrix for cellulose microfibrils. Hemicellulose is very hydrophilic, soluble in alkali and easily hydrolyzed in acids (John and Thomas 2007).

2.2.3 Lignin

Lignin is a complex hydrocarbon polymer with both aliphatic and aromatic constituents. They are totally insoluble in most solvents and cannot be broken down to monomeric units. Lignin is totally amorphous and hydrophobic in nature. It is the compound that gives rigidity to the plants. It is thought to be a complex, three-dimensional copolymer of aliphatic and aromatic constituents with very high molecular weight. Hydroxyl, methoxyl and carbonyl groups have been identified. Lignin has been found to contain five hydroxyl and five methoxyl groups per building unit. It is believed that the structural units of lignin molecule are derivatives of 4-hydroxy-3-methoxy phenylpropane. The main difficulty in lignin chemistry is that no method has been established by which it is possible to isolate lignin in its native state from the fibre. Lignin is considered to be a thermoplastic polymer exhibiting a glass transition temperature of around 90 °C and melting temperature of around 170 °C. It is not hydrolyzed by acids, but soluble in hot alkali, readily oxidized, and easily condensable with phenol (John and Thomas 2007).

2.2.4 Pectins and Waxes

Pectins are a collective name for heteropolysaccharides. They give plants flexibility. Waxes make up the last part of fibres and they consist of different types of alcohols.

2.3 Chemical Treatment of Lignocelluloses

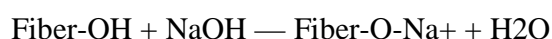
Production of lignocelluloses from palm oil empty fruit bunch involved some chemical treatment. Chemical pretreatments have been widely reported as a potential technique for lignocelluloses production using acid and alkaline (Mosier et al., 2005; Rebecca et al., 2007 and Ray et al., 2001). The first one is alkali treatment, Sodium

Hydroxide was used in this step. After done the alkali treatment, the sample will go for the acid treatment. In this treatment Hydrochloric acid was used. There are several sources in order to done the chemical treatment for palm oil empty fruit bunch.

2.3.1 Alkali Treatment

Alkali treatment of cellulosic fibers, also called mercerization, is the usual method to produce high quality fibers (Ray et al. 2001). Alkali treatment improves the fiber-matrix adhesion due to the removal of natural and artificial impurities. Moreover, alkali treatment leads to fibrillation which causes the breaking down of the 12 composite fiber bundles into smaller fibers. In other words, alkali treatment reduces fiber diameter and thereby increases the aspect ratio. Therefore, the development of a rough surface topography and enhancement in aspect ratio offer better fiber-matrix interface adhesion and an increase in mechanical properties. Alkali treatment increases surface roughness resulting in better mechanical interlocking and the amount of cellulose exposed on the fiber surface. This increases the number of possible reaction sites and allows better fiber wetting.

The following reaction takes place as a result of alkali treatment:



Alkali treatment influenced the chemical composition of the flax fibers, degree of polymerization and molecular orientation of the cellulose crystallites due to cementing substances like lignin and hemicelluloses which were removed during the mercerization process. Alkali treatment had a lasting effect on the mechanical behavior of flax fibers, especially on fiber strength and stiffness. Several other studies were conducted on alkali treatment. They reported that mercerization led to the increase in the amount of amorphous cellulose at the expense of crystalline cellulose and the removal of hydrogen bonding in the network structure.

The mechanism of NaOH pretreatment is postulated to be by saponification of intermolecular ester bonds crosslinking xylan hemicellulose and other polymeric materials, such as lignin or other hemicelluloses that was study by mission et al (2009).

2.4 Characterization of Lignocelluloses

There are several methods for characterize the lignocelluloses which are using Scanning Electron Microscope (SEM), Fourier Transform Infrared (FTIR) and Thermo Gravitation Analyzer (TGA).

2.4.1 Scanning Electron Microscope (SEM)

Scanning Electron Microscope (SEM) is a microscope that uses electrons instead of light to form an image. Since their development in the early 1950's, scanning electron microscopes have developed new areas of study in the medical and physical science communities. The SEM has allowed researchers to examine a much bigger variety of specimens.

The scanning electron microscope has many advantages over traditional microscopes. The SEM has a large depth of field, which allows more of a specimen to be in focus at one time. The SEM also has much higher resolution, so closely spaced specimens can be magnified at much higher levels. Because the SEM uses electromagnets rather than lenses, the researcher has much more control in the degree of magnification. All of these advantages, as well as the actual strikingly clear images, make the scanning electron microscope one of the most useful instruments in research today.

The SEM is an instrument that produces a largely magnified image by using electrons instead of light to form an image. A beam of electrons is produced at the top

of the microscope by an electron gun. The electron beam follows a vertical path through the microscope, which is held within a vacuum. The beam travels through electromagnetic fields and lenses, which focus the beam down toward the sample. Once the beam hits the sample, electrons and X-rays are ejected from the sample.

Detectors collect these X-rays, backscattered electrons, and secondary electrons and convert them into a signal that is sent to a screen similar to a television screen. This produces the final image.

2.4.2 Fourier Transform Infrared (FTIR)

FTIR (Fourier Transform Infrared) Spectroscopy, or simply FTIR Analysis, is a failure analysis technique that provides information about the chemical bonding or molecular structure of materials, whether organic or inorganic. It is used in failure analysis to identify unknown materials present in a specimen, and is usually conducted to complement EDX analysis.

The technique works on the fact that bonds and groups of bonds vibrate at characteristic frequencies. A molecule that is exposed to infrared rays absorbs infrared energy at frequencies which are characteristic to that molecule. During FTIR analysis, a spot on the specimen is subjected to a modulated IR beam. The specimen's transmittance and reflectance of the infrared rays at different frequencies is translated into an IR absorption plot consisting of reverse peaks. The resulting FTIR spectral pattern is then analyzed and matched with known signatures of identified materials in the FTIR library.

Unlike SEM inspection or EDX analysis, FTIR spectroscopy does not require a vacuum, since neither oxygen nor nitrogen absorb infrared rays. FTIR analysis can be applied to minute quantities of materials, whether solid, liquid, or gaseous. When the

library of FTIR spectral patterns does not provide an acceptable match, individual peaks in the FTIR plot may be used to yield partial information about the specimen.

Single fibers or particles are sufficient enough for material identification through FTIR analysis. Organic contaminants in solvents may also be analyzed by first separating the mixture into its components by gas chromatography, and then analyzing each component by FTIR.

2.4.4 Thermo Gravitation Analyzer (TGA)

Thermal methods investigate changes that occur upon heating a sample. Thermo gravimetric measures changes in the mass of a sample that occur when it is heated. These changes relate to the reactions during decomposition, the loss of volatile material and the reactions with the surrounding atmosphere. Thermo gravimetric analysis (TGA) continuously measures a weight of samples as a function of temperature and time. The sample is placed in a small pan or crucible connected to the microbalance and heated in a control manner and or held isothermally for a specified time. The atmosphere around the sample may consist of an inert gas, such as nitrogen, or reactive gas, such as air and oxygen. The heated program may start in an inert atmosphere and then be switched to air at a certain point to complete the analysis. Weight changes observed at specific temperature correlates to vitalization of sample components, decompositions, oxidation or reduction reactions or other reactions or changes. Temperature and mass data are collected and processed by computer dedicated to the system.

The TGA data gives information about such properties as; thermal stability, moisture or solvent content, additive or filler content, oxidation and decomposition temperatures and rate. Thermal events such as melting, glass transition and other

changes are not detected because there are no changes in the sample mass associated with this events. Any physical and chemical change involving mass may be studied.

CHAPTER 3

RAW MATERIAL AND EQUIPMENT

3.1 Raw Material and Equipment

The raw material in this research was palm oil empty Fruit bunch. The sample of palm oil empty fruit bunch was collected at FPISB Felda Chini 2 Sdn Bhd. The palm oil empty fruit bunch was got for free. It because, the palm oil mill produce a lot of palm oil empty fruit bunch as a residue ‘waste” and no value.



Figure 3.1: A lot of Palm oil empty fruit bunch produce from Palm Oil Mill.



Figure 3.2 : The Sampling Process.

3.1.1 Chemical

i. Sodium Hydroxide NaOH.

In this research the sodium hydroxide was used as a solvent in the process of alkali treatment. The function Sodium hydroxide is to break down the lignin bonding in the sample. Alkali treatment is the first treatment process to the lignocelluloses. The sample of palm oil empty fruit bunch was immersed in the solution of sodium hydroxide at constant concentration. The pretreatment of sample was carried out using 0.5 M NaOH . Sodium hydroxide was supplied by R and M Chemicals Malaysia to the FKKSA Laboratory.

ii. Hydrochloric Acid.

The sample was treated with hydrochloric acid after finish the pretreatment process. Hydrochloric Acid was used in the bleaching treatment and as a function to remove all the black liquor remained after alkali treatment. The concentration of hydrochloric acid is one of the parameter measured in this research. Concentration of acid was constant at 0.5 M for the parameter of temperature and sample size. In order to measured the parameter of concentration, the sample was run at the different concentration of hydrochloric acid which is 0.3 M, 0.4 M, 0.5 M, 0.6 M and 0.7 M. Hydrochloric acid was supplied by R and M Chemicals Malaysia to the FKKSA Laboratory.

3.1.2 Apparatus

There are list of the apparatus was used in order to done this research:

- i. Volumetric flask 1000ml.
- ii. Beaker 200 ml.
- iii. Stainless steel tray.
- iv. Glass rod.
- v. Spatula.
- vi. Thermometer.
- vii. Sieve.
- viii. Petri disk.
- ix. Filter funnel.
- x. Magnetic bar.

3.1.3 Equipment

There are list of equipment that was used in this experiment:

- i. Tyler mesh.
- ii. Balance.
- iii. Stirring hot plate.
- iv. Scanning Electron Microscope (SEM).
- v. Fourier Transform Infrared Spectroscopy (FTIR).
- vi. Thermo Gravitation Analyzer (TGA).

3.2 Methodology

There are several methods used to produces lignocelluloses from palm oil empty Fruit bunch. The overall methods can divided into four sections:

3.2.1 Preparation Sample of Palm Oil Empty Fruit Bunch

The sample will collect in plastic bags and stored in the cold room at 4°C- 8°C for one day. After that the sample was washed with water to make sure it free from dust and any contaminate particles. For the next step the sample was dried in an oven at temperature 103°C until constant weight will obtained. The sample of palm oil empty fruit bunch will cut into small size. The sample will blended to get the small particle range of 45µm until 1000µm. This process was shown in the flow chart as bellow. (Najafpour et al. 2007)